Integrated Assessment models for the water cycle: model evaluation and data needs

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Objective for Modeling the Water Cycle in an Integrated Assessment Model

- IAM modeling of water has two primary goals:
  - Quantify the demand for water in the future under various scenario drivers
    - Population, economic, climate policy, technology availability, etc. all affect future water demand

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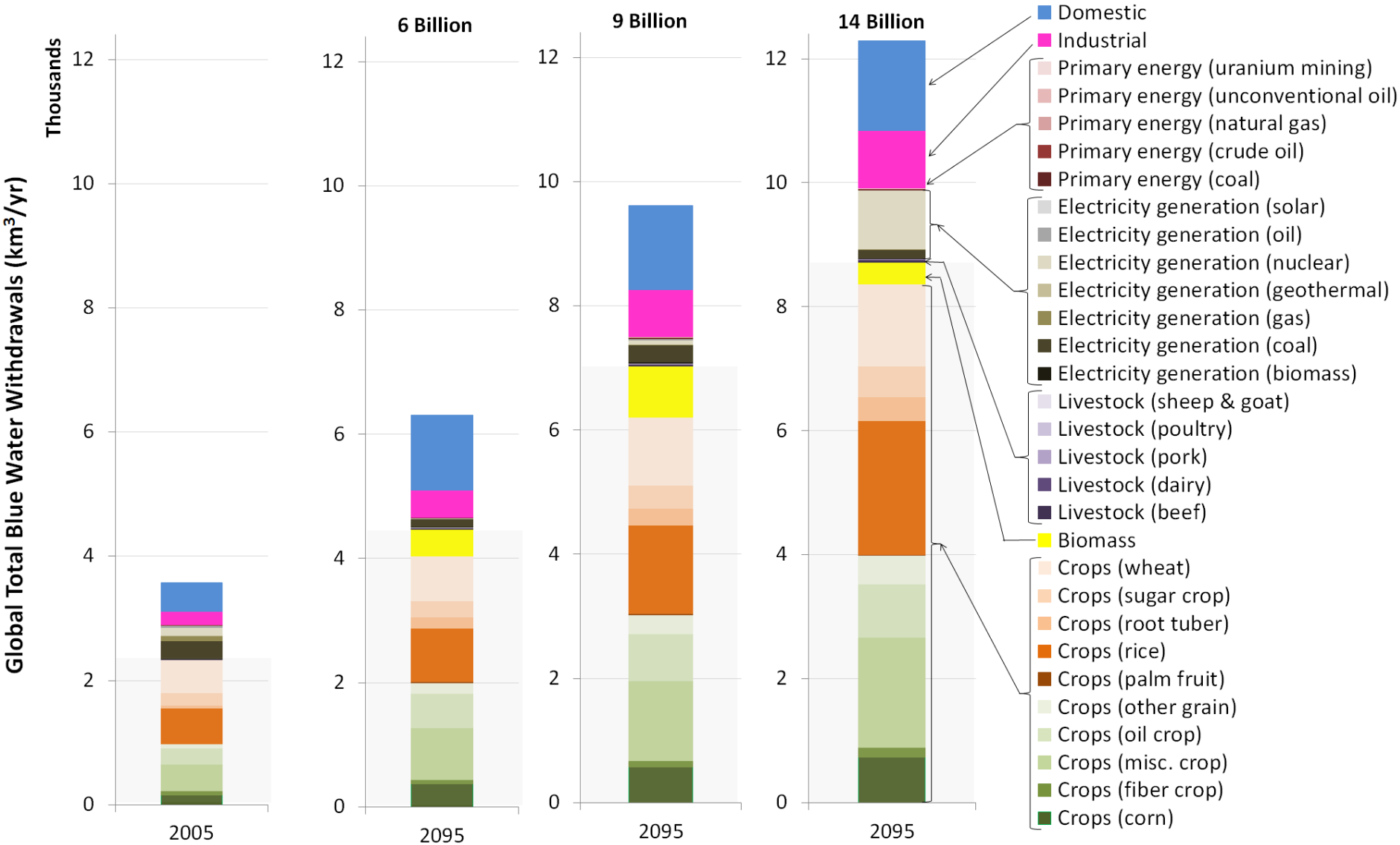

Global water demands by sector in years 2005 and 2095 (under three alternative scenarios with variations in technology, income, & population)

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  - Assess the effect of limits to water availability on human decisions
    - Limited water availability will influence technology choice in energy, agriculture, etc.

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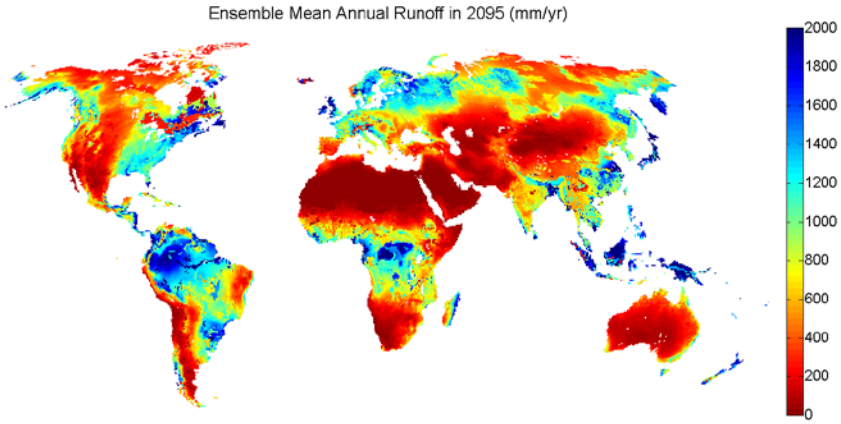

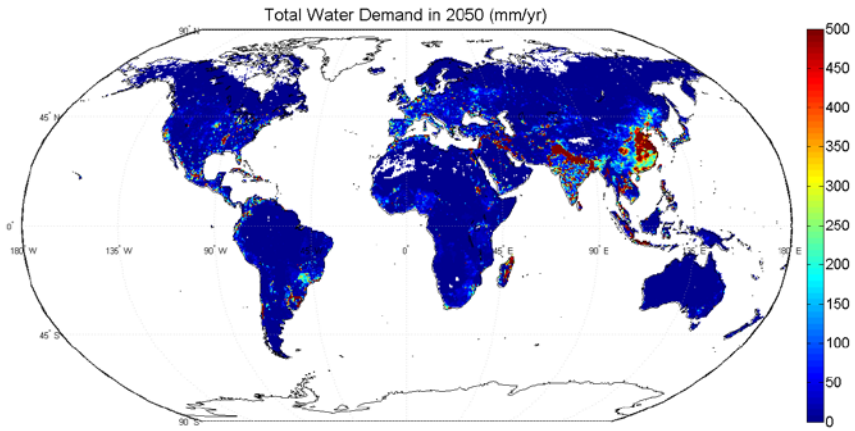

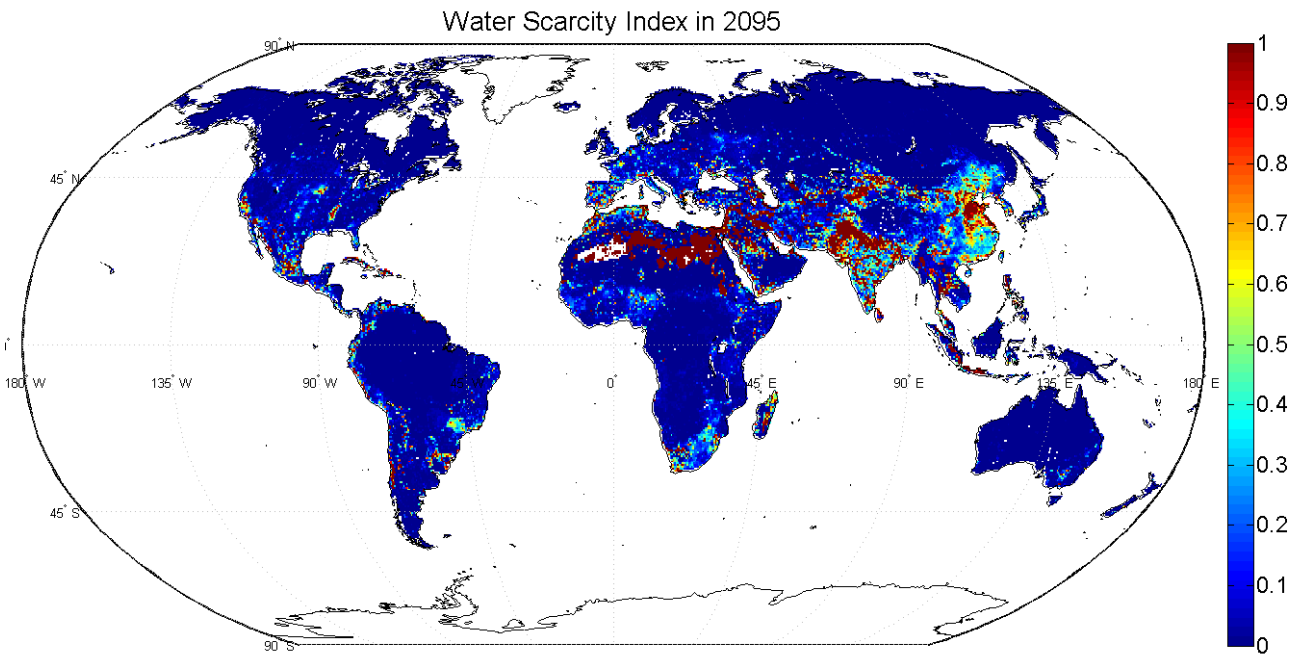

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- Accomplishing these goals requires:
  - A complete representation of water supply
  - A complete representation of water demand
  - A means of balancing the two

Data Requirements for Initialization and Evaluation: Water Demand

- Integrated assessment models need to represent all technologies and human activities that withdraw or consume water.
  - This includes energy, agriculture, industrial, and other uses of water.
- For initialization, inputs to an IAM include:
  - Water related parameters: withdrawal, consumption
  - Other parameters: cost, energy consumption, emissions, output, etc.
  - This data is required for every technology and human activity that consumes water.
  - Typically, IAMs operate at large spatial scales, but they will need water demand at smaller scales. As a result, IAMs will either need the inputs at a finer scale (e.g., water basin) or to develop methods for downscaling.
- For evaluation, IAMs need all of this data over a time series.

Data Requirements for Initialization and Evaluation: Water Supply

- Integrated assessment models need to represent all technologies and human activities that produce useable water.
  - This includes nonrenewable groundwater and desalinated water.
- Data required for modeling renewable water sources will be similar to that of physical models.
- Data required for nonrenewable groundwater and desalinated water:
  - IAMs need a mapping between cost and availability of these water sources.

Evaluating Integrated Assessment Models

- IAMs have predominantly relied on model comparison to evaluate their models. Hindcasting efforts are just beginning.

- Model comparison activities:
  - Largely focused on the energy component of IAMs
  - Land use model comparison efforts are just beginning
  - Comparison of water components is still some time off

- Hindcast efforts:
  - A couple of projects are underway to begin this effort.
  - There are a number of challenges:
    - Data
    - Difference between model objectives (long-term behavior) and real-world outcomes (short-term influences)
    - Compensating errors
    - Single component tests vs. full IAM diagnostics

Challenges

- Water Demand Data:
  - Generally available for developed countries. Data for developing countries is more sparse.
  - Data prior to 1995 is lacking. Some data sets are for a single year only (e.g., 2000)
  - Many datasets are at a country level. Spatial data is more limited.

- Water Supply Data:
  - Challenges that physical models face will largely apply to IAMs.
  - Additionally, IAMs will need representations of desalinated water (cost and energy use) and nonrenewable groundwater (cost of accessing and desalinating)

Challenges

- Additional Challenges:
  - Seasonality: IAMs typically operate at an annual timescale.
  - Addressing uncertainty: IAMs face a large number of uncertainties. The general approach is multiple scenarios. This is facilitated by using models that are quick.
  - Modeling human-decision making: IAMs are modeling humans. This requires representing how water markets will evolve in the future (e.g., price-based vs. rule-based), and how humans will respond to changes in water markets (e.g., price-induced conservation).